BIBLIOGRAPHIC INFORMATION

PB87-180774

Report on Efforts to Prevent Extinction of Kemp's Ridley Sea Turtle Through Head Starting,

Feb 87

by C. W. Caillouet.

PERFORMER: National Marine Fisheries Service, Galveston, TX. Galveston Lab.
NOAA-TM-NMFS-SEFC-188

Kemp's ridley sea turtle, Lepidochelys kempi, is one of eight species of sea turtles. Kemp's ridley and the olive ridley, L. olivacea, are the smallest of the sea turtles, reaching an adult weight close to 45 kg. Since 1973, Kemp's ridley, the rarest of the sea turtles, has been classified as endangered. The distribution of Kemp's ridley includes the Gulf of Mexico, the Atlantic coast of North America to Nova Scotia, and European Atlantic waters. As far as is presently known, the principal nesting area for Kemp's ridley is a 20-km stretch of oceanside beach bordering the Gulf of Mexico.

KEYWORDS: *Turtles, *Mexico Gulf, *Lepidochelys Kempi, *Endangered species.

Available from the National Technical Information Service, SPRINGFIELD, VA. 22161

PRICE CODE: PC AO2/MF A01

NOAA Technical Memorandum

NMFS-SEFC-188

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FEBRUARY 1987

U. S. DEPARTMENT OF COMMERCE
National Oceanic and
Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Center
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Galveston, Texas 77551-5997

NOAA Technical Memorandum NMFS-SEFC-188

Report on Efforts to Prevent Extinction of Kemp's Ridley Sea Turtle Through Head Starting

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February 1987

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A similar paper, in French (translation by Raymond Cayouette), has been published elsewhere (Caillouet, 1984).

This report should be cited as follows:

Caillouet, Charles Wax, Jr. 1987. Report on efforts to prevent extinction of Kemp's ridley sea turtle through head starting. NOAA Technical Memorandum NMFS-SEFC-188, i plus 20 p.

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Kemp's ridley sea turtle, Lepidochelys kempi (Fig. l), is one of eight species of sea turtles (Bjorndal and Balazs, 1983). Kemp's ridley and the olive ridley, L. olivacea are the smallest of the 'sea turtles, reaching an adult weight close to 45 kg. Sea turtles belong to the reptilian order Testudines, a group that arose during the early Triassic more than 185 million years ago (Ernst and Barbour, 1972). Despite this remarkably long and successful existence, many species of turtles are facing possible extinction<Since 1973, Kemp's ridley, the rarest of the sea turtles, has been classified as endangered under the U.S. Endangered Species Act and by the Convention on International Trade in Endangered Species of Wild Fauna and Flora.

The distribution of Kemp's ridley includes the Gulf of Mexico, the Atlantic coast of North America to Nova Scotia, and European Atlantic waters (Brongersma, 1972: Pritchard and Marquez, 1973) As far as is presently known, the principal nesting area for Kemp's ridley is a 20-km stretch of oceanside beach bordering the Gulf of Mexico near Rancho Nuevo, Tamaulipas, Mexico (Chavez et al., 1968). Each year, from April through July, nesting events referred to in Spanish as "arribadas," meaning arrivals, occur during which large aggregations of ridleys nest over a period of a few days (Chavez et al., 1968: Pritchard and Marguez, 1973; Casas-Andreu, 1978). Unlike other sea turtles, all of which nest at night, Kemp's ridley nests during the day, so its arribadas are more frequently observed. Single or scattered nestings have been reported for other nesting localities (Werler, 1951; Carr, 1961; Chavez and Kaufmann, 1974; Rabalais and Rabalais, 1980). It may take as many as 6-13 years of age before Kemp's ridleys reach maturity (Brongersma, 1972: Pritchard and Marquez, 1973). As shown from tagging studies at Rancho Nuevo, adult females may nest more than once during a season (Chavez et al., 1968), but all turtles at Rancho Nuevo do not nest every year (Marquez, 1983), which suggests that some turtles may not nest at all in some years or that they may nest elsewhere. Clutch size for Kemp's ridley at Rancho Nuevo averages slightly more than 100 eggs (Chavez et al., 1968).

It is not known how sea turtles find their way to a beach to nest, but several hypotheses have been proposed. Sea turtles may navigate by using visual cues and/or other sensory mechanisms, such as an internal "compass" which responds to the earth's magnetic field (Carr, 1967). Hendrickson

(1958) suggested that sea turtles that have never nested encounter others that have nested previously. Through such contacts, the novice turtles may follow experienced ones to the nesting beach, This theory has been referred to as "social facilitation" (Owens et al., 1982). Richard (1983) proposed a theory called "random drift" through which sea turtles may be conveyed passively to nesting beaches by oceanic currents. Recognition of the nesting beach may involve a chemical sense (Carr, 1967), and Kemp's ridley has a keen sense of smell (Grassman et al., 1984). This forms the basis for the hypothesis of "imprinting" which assumes that Kemp's ridley can "learn" and "remember" various odiferous substances characterizing the nesting beach and its adjacent waters (ibid.).

Using the working hypothesis that "imprinting" takes place in the eggs and/or hatchlings, biologists at the National Marine Fisheries Service's (NMFS) Southeast Fisheries Center (SEFC) Laboratory in Galveston, Texas, are giving Kemp's ridleys a head start by rearing them from hatchlings to yearlings in captivity, tagging them and releasing them into the Gulf of Mexico (Klima and McVey, 1981; Caillouet, 1984; Fontaine et al., 1985). This paper describes the Kemp's ridley head start research project which is part of an international program initiated in 1978 to prevent the possible extinction of this species.

POPULATION STATUS

In June 1947, Andres Herrera of Tampico, Mexico, filmed on one day an arribada comprised of an estimated 40,000 Kemp's ridleys nesting on the beach near Rancho Nuevo (Carr, 1963; Hildebrand, 1963). In 1960, there were estimated to be about 10,000 nesting ridleys, and by the time the Mexican Government began protective patrols of the beach in the mid-1960's, the number had dwindled to 2,000 (Marquez, 1983). An estimated 600 Kemp's ridleys nested in 1982 (ibid.), and now there are probably no more than 400 nesting females (Woody, 1986).

It is most likely that this spectacular decline in the Kemp's ridley population is the result of excessive exploitation by man; although predation and other natural causes cannot be ruled out as contributing factors. Until the turn of the century, sea turtles- (perhaps including Kemp's

ridley) were captured and shipped alive from south Texas parts to markets in New York (Gunter, 1981). Sea turtles are characteristically long-lived and well suited for an oceanic existence (Carr, 1967). However, their habit of nesting on beaches makes the adult females and their eggs particularly vulnerable to human exploitation and natural predation (Hildebrand, 1963: Pritchard and Marquez, 1973; Doughty, 1984). In addition, the hatchlings are exposed to mammalian, avian and crustacean predators as they crawl down the beach to the water and to predatory fish after they enter the shallow surf zone (ibid.). So little is known about the habits and whereabouts of sea turtles during their first year of existence in the wild that this period has been called the "lost year" (Carr, 1980). Sea turtles are captured incidentally in the nets of shrimp trawlers, and as a result thousands die annually (Watson and Seidel, 1980: Henwood and Stuntz, in press). Sea turtles also are caught in shark nets (Chavez, 1969; Pritchard and Marquez, 1973).

Climatolagical changes may affect sex ratios in sea turtle populations. Temperature during incubation of sea turtle eggs determines the sex ratio of hatchlings in the clutch (Yntema and Mrosovsky, 1980; Morreale et al., 1982; Standora and Spotila, 1985). Cooler incubation temperatures produce a preponderance of males and warmer temperatures produce more females. Thus, a warming trend in climate might possibly produce a preponderance of females, while a cooling trend a preponderance of males. In any case, such trends could lead to sex ratios too in-balanced for successful fertilization of eggs. The effect of temperature on sex ratios of Kemp's ridleys from artificially incubated eggs is being investigated, because it is of major importance to the success of head starting (Caillouet and Duronslet, 1985; Wibbels et al., 1985).

CONSERVATION EFFORTS

In January 1977, representatives of the Instituto National de la Pesca (INP) of Mexico, the United States Fish and Wildlife Service (FWS), the National Park Service (NPS), the NMFS, and the Texas Parks and Wildlife Department (TPWD) met in Austin, Texas USA to plan an international program to save Kemp's ridley sea turtle from extinction

(Klima and McVey, 1981). The cooperative program was implemented in 1978 and has three objectives:

(1) Protection of the primary nesting area, the adult female turtles and their eggs at the beach near Rancho Nuevo,

(2) evaluation of head starting, and

(3) establishment of a new nesting colony at the Padre Island National Seashore near Corpus Christi, Texas.

Head starting involves rearing Kemp's ridley in captivity from newly-hatched to yearling stages to increase survival during the critical first year of life (Klima and McVey, 1981; Mrosovsky, 1983: Fontaine et al., 1985). At the beach near Rancho Nuevo, plastic bags are used to collect eggs as they emerge from the cloaca of the females in order to prevent the eggs from coming in contact with the beach sand. Fewer than 5% of the estimated 70,000-90,000 eggs laid each year at the Rancho Nuevo beach are taken for head starting (Jack B, Woody, personal communication, July, 1984). The eggs are placed in polystyrene foam boxes containing beach sand taken from the Padre Island National Seashore, The boxes are transported by single-engine aircraft to the National Seashore where the eggs are incubated while still buried in the boxed sand.

When the hatchlings emerge, they are taken to the Padre Island beach and allowed to crawl down the beach into the surf. It is hoped that they become imprinted by exposure to the beach sand in the boxes during incubation and to the beach sand and surf after hatching. The hatchlings are then netted from the surf, put into boxes, and transported by NPS vehicle to Galveston, Texas. A few clutches, incubated, hatched and exposed to sand and surf at the Rancho Nuevo beach, also have been transported to Galveston for head starting.

Hatchlings received by the NMFS Galveston Laboratory are reared in captivity for one year or less. Healthy survivors in good condition are tagged and released into the Gulf of Mexico, in hopes that some will survive and instinctively return to Padre Island to nest as adults.

During the head starting of Kemp's ridley, special attention is given to behavior, diet, water quality, water temperature, and sanitation (Klima and McVey, 1981: Fontaine and Caillouet, 1985; Fontaine et al., 1985; Caillouet et al., 1986c). Young Kemp's ridleys are very aggressive, and when reared in groups, they bite and injure one another. The injuries become infected and result in poor health and death in some cases (Clary and Leong, 1984). However, the turtles thrive when reared individually. A commercially-manufactured, dry, floating, pelletized diet manufactured by PURINA has become the standard for head starting (see also Caillouet et al., 1986b and 1986c), but the natural diet consists of crustaceans, fish, jellyfish and molluscs (Pritchard and Marguez, 1973).

The first three years of head starting were exploratory (Klima and McVey, 1981; Fontaine et al., 1985). Thereafter, the rearing facilities and methods were improved and became more or less standardized (Fontaine et al., 1985). The number of live hatchlings received so far, representing year-classes 1978-1986, has totaled 15,260. Currently, about 1,740 Kemp's ridleys of the 1986 year-class are being head started. Plans are to expand the annual rearing capacity to 2,700 turtles.

Survivors in good health and condition that have been tagged and released so far into the Gulf of Mexico have totaled 10,792 (Caillouet et al., MSa). Most of the tagged turtles were released off the coast of the National Seashore (Caillouet et al., 1986b; Fontaine et al., MS). Some were released off the upper coast of Texas, in Nueces and Copano Hays near Corpus Christi, Texas, off the west coast and southern tip of Florida, and in the Hay of Campeche, Mexico (Klima and McVey, 1981: McVey and Wibbels, 1984; Wibbels, 1984: Caillouet et al., MSa; Fontaine, et al., MS). Of the total released, 492 had been recovered as of 30 September 1986 (Caillouet et al., MSa). Recoveries have been reported from the Gulf of Mexico, from the east coast of the United States, and from the European Atlantic coast, in a distribution comparable to that reported in the literature (e.g., Brongersma, 1972; Pritchard and Marquez, 1973) and as indicated by data from the Sea Turtle Stranding and Salvage Network (Fontaine et al., MS). One recovered from the coast of Morocco may be the first record of Kemp's ridley for the northwest coast of Africa (ibid.). These recoveries show that head started turtles survive, grow and migrate in the wild.

Carr (1980) believes that Kemp's ridleys that leave the Gulf of Mexico and migrate along the Atlantic coasts of North America and Europe may be strays doomed to die as hapless wanderers never finding their way back into the Gulf of Mexico to mate and nest. On the other hand, it seems unlikely that such transoceanic migratory behavior would have evolved without having some survival value to the species. Before the Rancho Nuevo nesting colony became known to sea turtle biologists, Carr (1957) and Carr and Caldwell (1958) suggested that the northwest coast of Africa might be a possible nesting site. After the discovery of the Rancho Nuevo nesting site was announced, interest in a search for a northwest African nesting site waned. Based on examination of the literature, recoveries of tagged Kemp's ridleys, and stranding records, Fontaine et al. (MS) speculated that Carr (1957) and Carr and Caldwell (1958) may have been correct in proposing a northwest African nesting site, but this remains unproven.

Head started turtles are tagged so that they can be identified if recovered later on. According to Carr (1967), "a good tag is one that can be Quickly put on, that interferes little with the movements and peace-of-mind of the animal; that will stay on a long time - if the animal is one that lives a long time, as a turtle does: that is inscribed with clear directions for its return: and that offers a reward to the one who sends it back." Unfortunately, no tag currently in use fulfills all these criteria. To be successful in testing efficacy of head starting as a conservation method, any tag used must be retained by the turtles at least for the length of time it takes them to mature and nest. Furthermore, the tag must be recognizable by those who examine nesting turtles. The standard tags for head started Kemp's ridleys have been metal tags attached to the trailing edge of a front flipper (Fig. 2). Some of the turtles also have been marked with "living tags" formed by excision and transplantation of a 2-3 mm sliver of light-colored plastron tissue to a scute on the darker carapace. 'This grafting technique was developed by Hendrickson and Hendrickson (1981). All members of a year-class are marked on the same carapace scute, and a different scute is selected to represent each year-class (Caillouet et.al., 1986a). A binary-coded, magnetic metal tag was

implanted near the distal end of a front flipper of all head started turtles of the 1984 and 1985 year-classes. Multiple marking should increase the probability of retention of at least one recognizable tag. As an experiment, 50 ridleys of the 1984 year-class were "flipper-printed," by making plastic casts of potter's clay impressions of the flippers. Plans are to use computer imagery to characterize and compare such "prints" as a means of identifying individuals (Caillouet et al., MSb). Multiple-marked Kemp's ridleys are being held in captivity beyond the first year, in part to study tag retention and recognition of individuals.

Head started turtles unquestionably have a much higher survival during their first year of life than those that must fend for themselves in the wild from the time of hatching. However, after head started turtles are released, the effects of prior human care and feeding may influence their behavior in such a way that renders them more susceptible to natural predation or recapture by man, or less successful in obtaining food than their completely wild counterparts. Conversely, perhaps some head started turtles will overcome the hazards of the wild and survive, mature, and nest successfully to form new colonies or bolster the existing one. The odds against survival of thousands of head started turtles may be so great that few if any may come ashore to nest in future years. Yet, the species is so close to extinction that such risks seem insignificant in contrast to what might be accomplished and learned by testing head starting. The turtles are long-lived and could reproduce for a number of years, once they survive to maturity. The hundreds of head started turtles tagged and released each year are significant when compared to the current scarcity of nesters.

The primary objective of head starting will be fulfilled only when surviving adults return to nest where they were "imprinted", as hatchlings. Based upon successful reproduction of 7-year-olds in captivity, enough time has elapsed for at least some of the head started survivors to have reached the reproductive stage, but none have been observed on the nesting grounds so far. In the interim, valuable knowledge has been gained by observing Kemp's ridley in captivity and by monitoring its migrations, growth, and survival in the wild.

OTHER CONSERVATION EFFORTS

Rearing Kemp's ridley in captivity has afforded an opportunity to develop a captive brood stock. Of the 264 Kemp's ridleys reared, tagged and transferred to cooperating organizations, 110 survivors are now distributed among Pan American University (South Padre Island, Texas), Sea-Arama Marine world (Galveston, Texas), Dallas Aquarium (Dallas, Texas), Marine Life Park, Inc. (Gulfport, Mississippi), Bass Pro Shops (Springfield, Missouri), Gulfarium (Fort Walton Reach, Florida), Clearwater Marine Science Center (Clearwater, Florida), Miami Seaquarium (Miami, Florida), Theater of the Sea (Islamorada, Florida), Marineland, Inc. (St. Augustine, Florida), Sea World of Florida (Orlando, Florida), North Carolina Marine Resources Center (Kure Beach, NC), New England Aquarium (Boston, Massachusetts), and Cayman Turtle Farm [1983] Ltd. (Grand Cayman Island, BWI). Currently, they range in age from 2 to 8 years old.

In May 1984, eggs were laid by two of the captive-reared 5-year-old females at the Cayman Turtle Farm [1983] Ltd. (Wood and Wood, 1984). Only three eggs hatched, indicating that copulation with and fertilization by captive-reared males had taken place, but the hatchlings died. No nestings were reported for the 1985 season, but some of the 7-year-olds nested in spring 1986, and viable hatchlings were produced (James Wood, Cayman Turtle Farm, personal communication, September 1986). The nestings at age 5 represented the earliest documented age for nesting in the species, albeit in captivity, and the successful hatches in captive 7-year-olds provided the needed breakthrough to make captive propagation feasible.

Because sea turtles are caught incidentally in commercial shrimping operations, methods have been developed to resuscitate and release turtles that happen to get caught in this way (Watson and Seidel, 1980). The NMFS SEFC Laboratories in Bay St. Louis and Pascagoula, Mississippi, developed a Turtle Excluder Device (also Trawling Efficiency Device or TED; Fig. 3) for shrimp trawls that allows captured turtles to escape from the nets during trawling operations (Taylor et al., 1985). As fringe benefits, the "TED" reduces the incidental catch of finfish without reducing the catch of shrimp (Watson, Mitchell and Shah, 1986).

The Sea Turtle Stranding and Salvage Network has aided reporting of sea turtles found stranded on beaches, either alive or dead. It provides one useful index to sea turtle mortality. Because unauthorized possession of sea turtles is punishable by law under the U.S. Endangered Species Act, local, federal or state law enforcement agents should be contacted when a stranded sea turtle is found. Large numbers of sea turtles found stranded on beaches of the upper Texas Coast in 1985 and 1986 led to concerns that the turtles might be injured or killed by underwater explosives used to salvage petroleum platforms from depleted oil fields in the Gulf of Mexico. As a result, NMFS entered into a Section 7 consultation with the Department of Interior's Minerals Management Service (MMS), under the Endangered Species Act, and 30-day advanced notice is now required before such salvage operations. This allows time for NMFS and MMS to prepare for study of impacts on protected species.

THE FUTURE

Restoring the population of Kemp's ridley will not be an easy task (Mrosovsky, 1983). Conservation and management of Kemp's ridley and other sea turtles require international cooperation among researchers and conservationists (Bjorndal and Balazs, 1983). Of major importance is protection of nesting turtles and their nests from poaching and predation. Oceanside reserves and refuges have been created to insure that breeding colonies of sea turtles and their nests are not further disturbed. Such protection of the Rancho Nuevo beach by the Mexican government, including patrols during the nesting seasons, has virtually eliminated poaching and dramatically reduced predation on the beach to the extent that such-losses are inconsequential and no longer prevent Kemp's ridley recovery (Jack Woody, FWS, personal communication, January 1986). Marketing of sea turtles and their products is being controlled to allow sea turtle populations to recover. The United States and other nations prohibit capture of sea turtles and have banned commercial uses, importation and exportation of sea turtles and their products, whether caught or produced by turtle farms.

continued protection of nesting areas and prohibitions on the possession and sale of Kemp's ridley sea turtles, their eggs and other products should enhance the production and survival of young and increase

recruitment to the nesting population. Continued head starting, based on a small fraction of the eggs produced at Rancho Nuevo each year, not only can provide a steady flow of thousands of yearlings to the Gulf of Mexico, but also a supply needed to maintain a captive stock of breeders as a "safety net" for the species. Head starting also provides otherwise unavailable opportunities for research that contributes to a better understanding of the biology of Kemp's ridley sea turtle and the problems that this species faces. Expansion of the use of the TED should increase the survival of Kemp's ridleys caught incidentally during shrimping operations. Further study of impacts of underwater explosions on sea turtles will be required before it can be determined whether or not this is a significant cause of mortality.

If Kemp's ridley sea turtles, marked or unmarked, begin showing up in numbers to nest on the beach at the Padre Island National Seashore, or if the nesters increase in numbers elsewhere, this will indicate that the combined conservation efforts are succeeding. Only time will tell how successful these efforts will be.

ACKNOWLEDGMENTS

The Kemp's ridley sea turtle head start research project has been conducted under Permits ABC-IV-0751/8676, ABC-IV-1258/4287, 242-0180-3794, 242.2-2610, 242.2-00026/1147, CG-115-900 (and Diplomatic Note No. 316502), 2534 (and Diplomatic Note No. 301976), 301271 (and Diplomatic Note No. 174) and 150486-333-01-0750 (and Diplomatic Note No. 30132) from Mexico's Departmento de Pesca (Instituto National de la Pesca), Endangered and Threatened Species Permits PRT 2-1770, PRT 2-4481, PRT-676379 and PRT-689914 from the U. S. Fish and Wildlife Service, Scientific Permit No. SPO73 from the Texas Parks and Wildlife Department, Scientific Permit TP-015 from the Florida Department of Natural Resources, and Permits No. US-701414, US-707274 and US-675990 from the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Many individuals are playing important roles in the international Kemp's ridley recovery program, including Rene Marguez Millan (INP), Jack

Woody (FWS), Milford Fletcher (NPS), Patrick Burchfield (Gladys Porter Zoo), Edward Klima (NMFS), Donna Shaver (NPS), Clark Fontaine (NMFS), and their staffs. Carole Allen, Chairperson, and members of HEART (Help Endangered Animals - Ridley Turtles), a special committee of the Piney Woods Wildlife Society of North Harris County College, Houston, Texas, deserve especial recognition for there perservering efforts in promoting public awareness and support of the head start research project.

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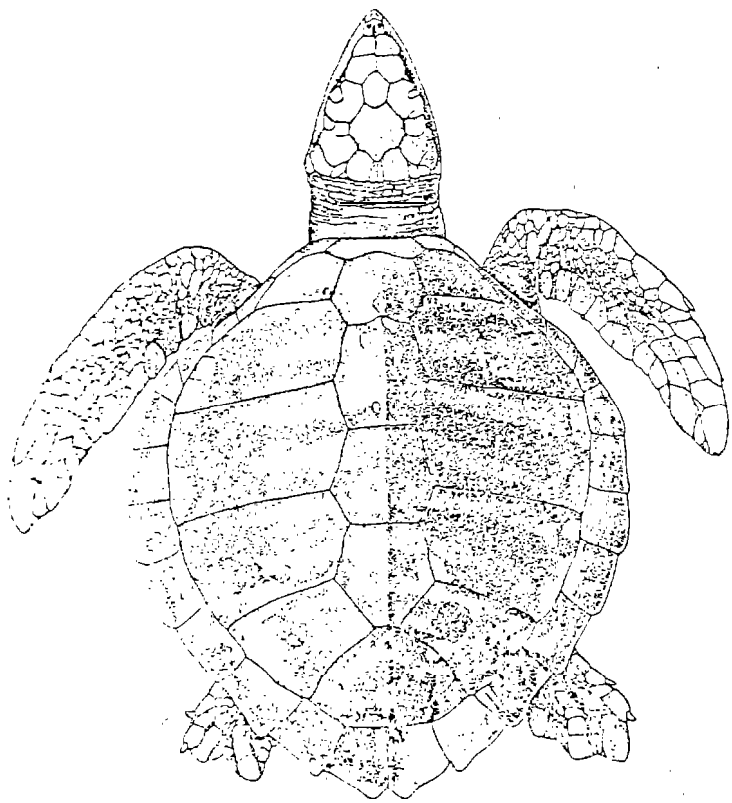

Figure 1. Dorsal view of Kemp's ridley sea turtle, Lepidochelys kempi. From Brongersm (1972, Plate 10) with permission of Rijksmuseum van Natuurlijke Historic, Leiden, the Netherlands.

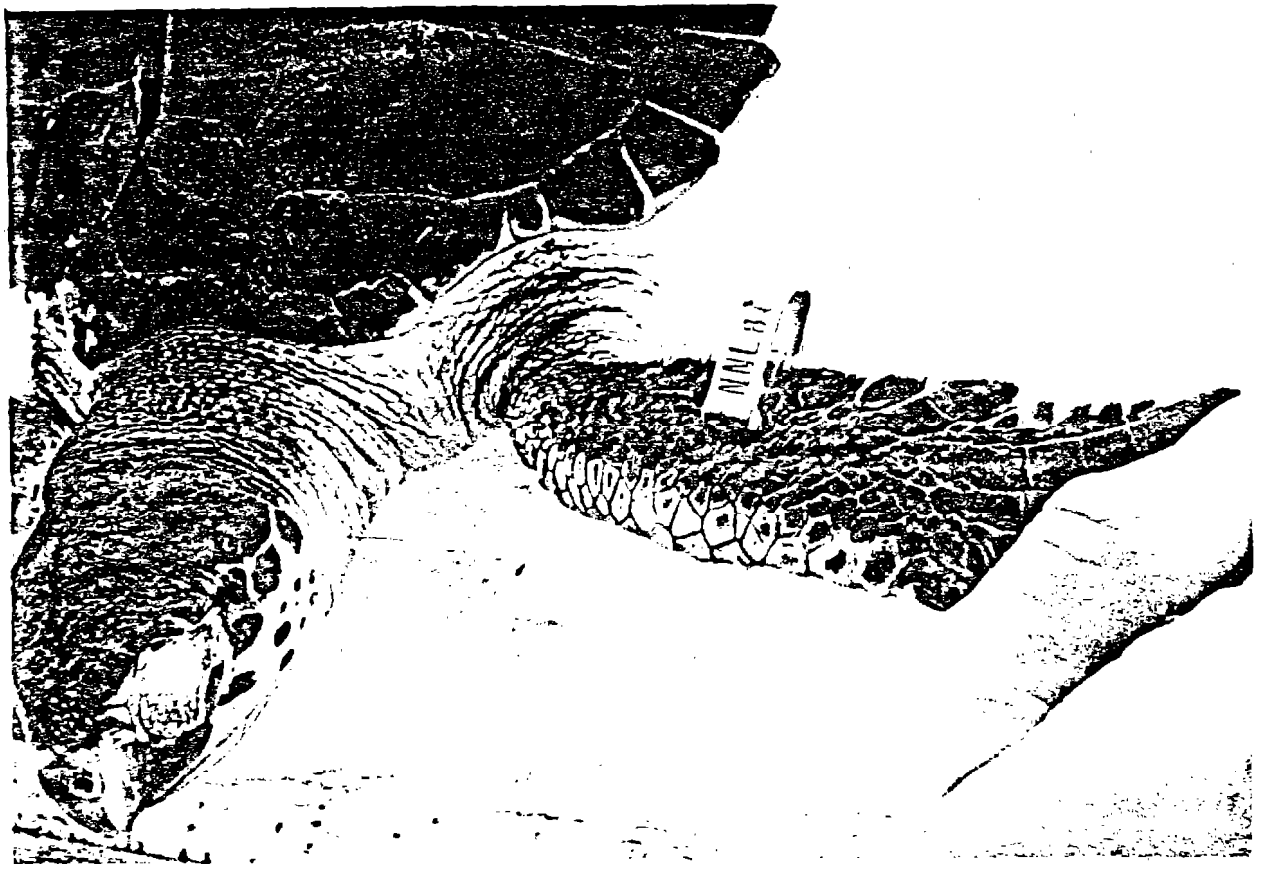

Figure 2. Head started yearling Kemp's ridley sea turtle, Lepidochelys kempi, with metal tag on its left front flipper. Photo by Daniel Patlan.

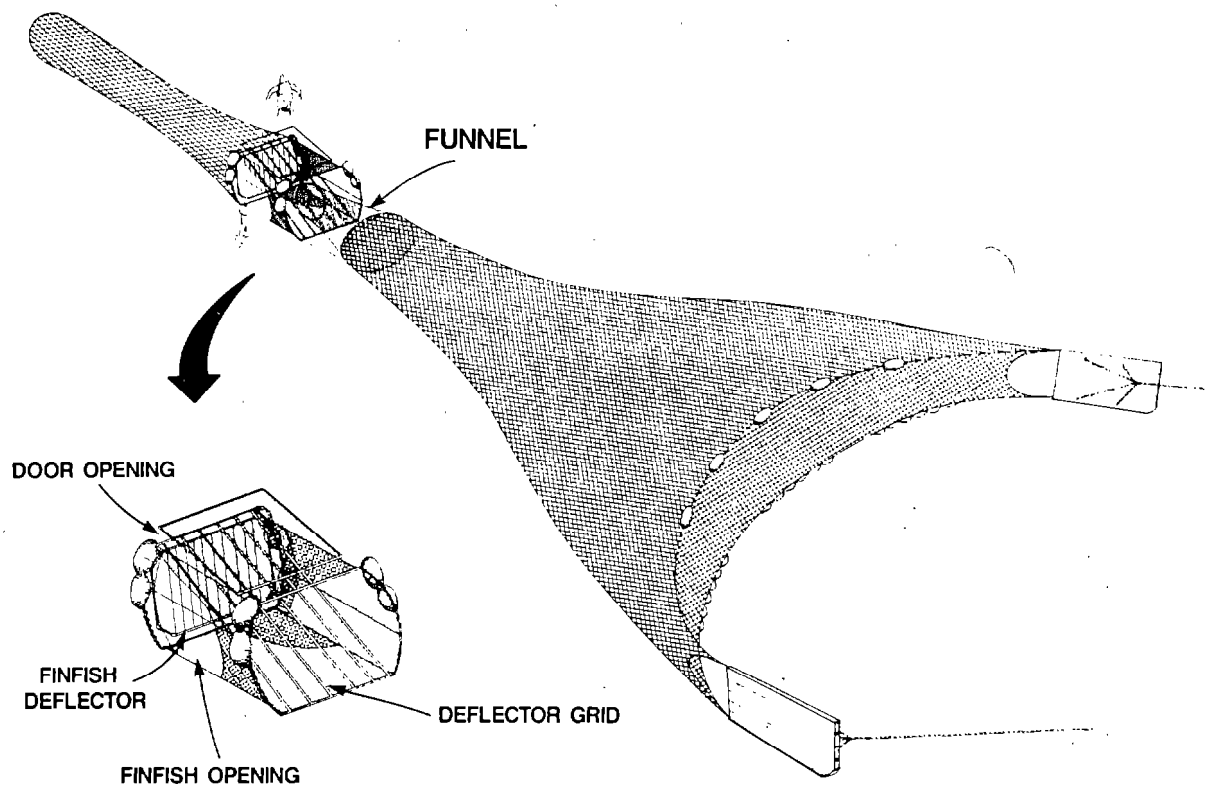

Figure 3. Turtle Excluder Device (TED) or Trawling Efficiency Device shown in cutaway diagram of a shrimp trawl and with escaping sea turtle (from Watson et al., 1986).